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Field Evaluation of Phloem-Mobile Acephate for Suppression of Southern Pine Beetle[1]

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Using aerially-applied acephate (Orthene 75S), a phloem-mobile insecticide, to protect loblolly pine (*Pinus taeda* L.) against attack by southern pine beetle (*Dendroctonus frontalis* Zimmermann) does not show promise. In a field experiment near Jacksonville, North Carolina, in 1975, basipetal transport of acephate was assessed. Analyses of residues and gallery length reduction showed that this insecticide did not translocate from the foliage to the phloem of the bole when trees were sprayed in October at the rates of 1.1 and 2.3 kg. a.i./185 *l*/ha. To apply acephate at higher rates, even with precise timing, is likely to be unsatisfactory.

Retrieval Terms: Pinus taeda, Dendroctonus frontalis, insecticides, acephate, Orthene 75S, Monitor (insecticide), aerial spraying, phloem transport

Current methods to remove trees infested with southern pine beetle (*Dendroctonus frontalis* Zimmermann) include salvage removal, pile-and-burn, chemical treatment, and cut-and-leave. Salvage removal, the method most widely used, is limited by markets and accessibility. The last three methods can be extremely labor-intensive and therefore, costly, or they can pose a risk to environmental safety.

An economical method is needed to prevent spot growth—increase in size of a small localized epicenter of infested trees—resulting from southern pine beetle infestations. The major problem in preventing or reducing spot growth is the inability to treat trees adjacent to brood trees before damage occurs. An insecticide that can flow through the phloem tissue of the tree could be absorbed by the needles and translocate to phloem tissue in the main trunk where beetles are feeding or may be feeding in the near future. Applying the insecticide by helicopter and spraying from low altitudes could further ensure that the chemical would be confined to the spot and the surrounding uninfested trees.

Two insecticides—acephate (Orthene 75S) and methamidophos (Monitor)—showed limited phloem mobility in laboratory tests.[2] When sprayed at the rate of 2.37 g/*l* on foliage of potted saplings of balsam fir (*Abies balsamea* [L.] Mill.) or ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.), each of the insecticides tested translocated to the trunk.[3]

The potential for basipetal transport of acephate and methamidophos in 15-year-old slash pine (*Pinus elliottii* Engelm. var. *elliottii*) trees was investigated in 1974, in Olustee, Florida.[4] Analysis of the residues extracted from the phloem tissue demonstrated that neither insecticide transported basipetally to the phloem tissue in the trunk in concentrations greater than 2 ppm. Improper time of application was thought to be the reason for poor basipetal transport. Apparently the flush of downward-moving photosynthate that normally occurs in trees before hardening-off for the winter at more northerly sites does not occur, or occurs at some other time, in Florida.

A similar experiment was done in Bolton, North Carolina, in October 1974, when leaves of hardwoods showed fall coloration and when night temperatures fell to about 5°C.[5] Both acephate and methamidophos were translocated basipetally. Spray applied at this colder site apparently coincided with downward movement of sap. We concluded, therefore, that the insecticides translocated downward with the natural photosynthate.

We preferred to use acephate for the study reported in this note. It is an acetyl derivative of methamidophos and is considered to be more acceptable on the basis of environmental safety because of its reduced toxicity to mammals. Phloem transport characteristics are similar to those of methamidophos.

To access the basipetal cotransport of acephate with photosynthate, mature loblolly pine (*Pinus taeda* L.) trees were sprayed by helicopter near Jacksonville, North Carolina, in October 1975, at the rate of 1.1 and 2.3 kg a.i./185 *l*/ha. Analyses of insecticide residues in phloem tissue and gallery length in cut boles showed that this insecticide did not translocate from the foliage to the phloem of the bole. Therefore, to apply acephate at rates higher than 2.3 kg/ha, even with precise timing, does not hold much promise as a prophylactic treatment for southern pine beetle.

METHODS AND MATERIALS

Helicopter Application of Acephate

Twelve plots (0.49 ha each) were set up on the Camp LeJeune Marine Corps base, near Jacksonville, North Carolina. Loblolly pines used in this test were uniform in size: diameter-at-breast-height (d.b.h.) ranged from 25 to 40 cm, total height ranged from 17 to 24 m, and age ranged from 24 to 30 years. To prevent contamination of the bole by acephate during treatment, all test trees in the plots were sheared, marked, and masked at three levels. Masking consisted of wrapping the sample zone with polyethylene sheeting (7.62 cm wide, 6 mil thickness) in an overlapping spiral, from the bottom of the tree upward.

Plots were sprayed by a Bell GB47-B2[6] helicopter on October 1, 1975. A conventional spray boom equipped with T-jet 8020 flat-fan nozzles was used. Winds did not exceed 3 knots at the time of application. Eight plots were sprayed with acephate, four at the rate of 1.1 kg/185 *l*/ha and four at the rate of 2.3 kg/185 *l*/ha. The remaining four plots were check plots.

Sampling for Residue Analysis

At the various sampling intervals, bark discs (5.1 cm o.d., 20.3 cm^2) were taken from two treated trees on each of the 12 plots at three vertical sampling zones—upper, middle, and lower third of the tree bole. The two disc samples were taken at 180° from each other on the bole circumference. Each disc was bagged, frozen in dry ice, and shipped by air to Berkeley, California, for residue analysis. Each sample included all of the outer bark, the functional phloem-cambium-xylem tissues, and about 1 cm of wood. In the laboratory, the discs were removed from cold storage, and the phloem tissue dissected with a spatula and razor blades. The excised phloem tissue was weighed and prepared for residue analysis.[7]

In the laboratory, qualitative and quantitative analyses of acephate and methamidophos are done simultaneously. Methamidophos is a metabolite of acephate and is recovered from tissue by the same techniques that apply to acephate.

Cut Bolt Bioassay

Each week for 4 weeks, three trees from each plot were felled and 0.5-m bolts cut from the upper, middle, and lower levels in the bole. To prevent loss of water, the ends of cut boles were dipped in hot paraffin within 24 hours of harvest. Ten each newly emerged male and female southern pine beetle adults were placed on each bolt within a fiber drum covered with a 32-mesh saran screen. After 15 days, the bark was peeled from the bolts and the total length of all egg galleries measured. Differences in gallery length were tested by analysis of variance ($\alpha = 0.05$).

RESULTS AND DISCUSSION

We did not observe significant quantities of either acephate or methamidophos in the phloem tissue of treated trees. Residue analysis of the tissue failed to detect more than 1 ppm of either insecticide. Bioassays with cut boles also showed that acephate did not translocate downward into the cambium in sufficient quantities to affect attacks of southern pine beetle.

Length of egg gallery per attacking adult beetle was compared between boles cut from untreated and treated trees (*table 1*). No significant decrease in gallery length was found between either of the acephate treatments (1.1 or 2.3 kg/185 *l*/ha).

The phloem mobility of the insecticides is not in question, however. Previous studies showed that both acephate and methamidophos have some phloem mobility.[8] In the 1974 experiment at Olustee, Florida, foliage of slash pine was sprayed from a cherry picker until runoff with insecticide formulated at a concentration of 2.4 g/*l* using a hydraulic sprayer. Although both acephate and methamidophos transported basipetally to the trunk phloem, they did so in concentrations ≤ 2 ppm. In the 1974 experiment in Bolton, North Carolina.

Table 1—*Length of egg galleries per attacking southern pine beetle adults after feeding on bolts cut from acephate-treated and untreated loblolly pines*[1]

Treatment (kg/185 *l* H_2O/ha)	Upper bole				Middle bole				Lower bole			
	Week				Week				Week			
	1	2	3	4	1	2	3	4	1	2	3	4
2.3	5.8	12.0	19.7	15.8	3.4	17.2	23.4	17.9	18.1	23.3	20.8	19.5
1.1	13.0	17.0	23.7	21.1	7.9	14.3	24.3	16.4	40.5	16.1	25.1	19.6
Check	19.7	18.3	[2]21.5	14.1	7.0	16.1	19.7	16.8	8.1	17.4	[2]30.5	15.9

[1] Adult beetles in bole divided into total length of galleries. Each value is the mean of 8 to 12 replications at that bole level.
[2] Individual galleries could not be distinguished.

acephate or methamidophos was sprayed on mature loblolly pine from a cherry picker at a concentration of 4.7 g/*l*. Both insecticides translocated basipetally. Residues were present in a gradient: higher levels in the upper bole to lower levels in the lower bole. Concentrations of acephate reached as high as 113 ppm in the upper zone of the trunk 5 days postspray. Mean concentration of acephate was 78 ppm. Methamidophos residue concentrations were considerably less than those of acephate. Residues of either insecticide, however, were barely detectable 90 days postspray.

In the Bolton, North Carolina test, maximum concentration of acephate transported to the phloem tissue was 113 ppm when foliage was sprayed to runoff and timing was right, and the residues metabolized rather quickly. Acephate has a feeding toxicity (LC_{50}) in the range of 100 to 500 ppm.[9] In the Bolton test, therefore, acephate was phloem-mobile only into the lowest part of its toxicity range.

In the study reported here, acephate applied from a helicopter at a much higher rate—2.3 kg/185 *l*/ha, or about 124 g/*l*, as opposed to 2.4 g/*l* sprayed from cherry pickers at Olustee and 4.7 g/*l* sprayed at Bolton—failed to transport successfully in the phloem tissue. Insufficient acephate impinged on the foliage and, as in the Olustee experiment, downward movement of the photosynthate did not occur at the time of application.

These results suggest that application of acephate at rates higher than 2.3 kg/185 *l*/ha—even with precise timing—will not provide a successful treatment for infestations of southern pine beetle.

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NOTES

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[2] *O,S*-dimethyl-N(acetyl) phosphoramidothioate, Orthene; *O,S*-dimethylphosphoramidothioate, Monitor.

[3] Crisp, C.E., and M. Page. Unpublished data on file at the Pacific Southwest Forest and Range Experiment Station, Forest Serv., U.S. Department of Agriculture, Berkeley, Calif.

[4] Williams, C.B., C.E. Crisp, G.D. Hertel, and P.E. Buffam. 1974. Small scale field experiment to evaluate the phloem mobility of Orthene and Monitor in southern pines. Unpublished data on file at the Pacific Southwest Forest and Range Experiment Station, Forest Serv., U.S. Department of Agriculture, Berkeley, Calif.

[5] Crisp, C.E. Unpublished data on file at the Pacific Southwest Forest and Range Experiment Station, Forest Serv., U.S. Department of Agriculture, Berkeley, Calif.

[6] Trade names and commercial enterprises or products are mentioned solely for necessary information. No endorsement by the U.S. Department of Agriculture is implied.

[7] Richmond, C.E., C.E. Crisp, J.E. Larson, and G.R. Pieper. 1979. *A simple method for assessing acephate and methamidophos residues in plant tissue*. Bull. Environ. Contam. Toxicol. 22:512-516.

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